REMARKS

Applicants affirm the election, without traverse, of claims 1-10 made by Applicants' representative on March 9, 2005, in response to the Examiner's oral restriction requirement between Group I, including claims 1-10, and Group II, including claims 11-21.

By the present Amendment, Applicants have amended the title of the application, and amended claims 6, 7, 9, and 10 to more appropriately define the invention. The claim amendments are fully supported by the originally filed application. See, e.g., specification at page 33, line 11 - page 34, line 19, and Figs. 10A, 10B, and 11A-11E. Claims 1-21 are pending, with claims 11-21 withdrawn as directed to non-elected invention.

In the Office Action, the Examiner objected to the title as not descriptive; objected to claim 2 as dependent upon a rejected base claim; rejected claims 4, 6, and 7 under 35 U.S.C. § 112, second paragraph, as indefinite; rejected claims 1 and 3-10 under 35 U.S.C. § 102(e) as anticipated by Kikitsu et al. (U.S. Patent Pub. No. 2004/0131890); and rejected claim 9 under 35 U.S.C. §§ 102(a), (b), and (e) as anticipated by Ishida et al. (U.S. Patent No. 6,347,016). Claim 2 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

As the Examiner suggested, Applicants have amended the title in the manner suggested by the Examiner and request that the objection thereto be withdrawn.

The Examiner rejected claim 4 under 35 U.S.C. § 112, second paragraph, alleging that the term "fine" is a relative term not defined by the claim or specification. See Office Action at 5. Applicants note, however, that the term "fine particle" is a well

defined and commonly accepted term in the field of magnetic devices. See, e.g., Synthesis of monodisperse cobalt nanocrystals and their assembly into magnetic superlattices (invited), by Shouheng SUN et al., Journal of Applied Physics, vol. 85, no. 8, pp. 4325-30, April 15, 1999, which was submitted in the Information Disclosure Statement filed on November 7, 2003, and the contents of which have been incorporated by reference (specification at 27). See also, e.g., Magnetically induced self-organization, by B.A. Jones et al., Journal of Applied Physics, vol. 97, 10J312, 2005, a copy of which is attached for the Examiner's reference. Applicants respectfully request the withdrawal of the rejection of claim 4 under 35 U.S.C. § 112, second paragraph.

Applicants submit that the amendments to claims 6 and 7 overcome the rejection of these claims under 35 U.S.C. § 112, second paragraph, and request that the rejection be withdrawn.

Regarding the rejection of claims 1 and 3-10 under 35 U.S.C. § 102(e) as anticipated by Kikitsu et al., Kikitsu et al. does not qualify as a prior art under 35 U.S.C. § 102(e), because Kikitsu et al. has a filing date of September 24, 2003, while the present application is entitled to the filing date of Japanese Patent Application No. 2002-326057, November 8, 2002, of which the present application claims priority. Applicants are currently preparing an English translation of Japanese Patent Application No. 2002-326057 for submission to the Patent Office to perfect the claim of priority pursuant to M.P.E.P. § 706.02(b). When the translation is complete, Applicants will submit the translation to the U.S. Patent and Trademark Office in a supplemental response. Applicants respectfully request that the Examiner hold the rejection of claims 1 and 3-10

under 35 U.S.C. § 102(e) as anticipated by Kikitsu et al. in abeyance and reconsider and withdraw the rejection upon receiving the translation of the priority document.

The rejection of claim 9 under 35 U.S.C. §§ 102(a), (b), and (e) as anticipated by Ishida et al. should be withdrawn, because Ishida et al. fails to teach each and every element of claim 9.

Claim 9 recites a magnetic recording medium that includes

> a flat non-magnetic substrate;
>
> a ferromagnetic layer formed on the non-magnetic substrate, the ferromagnetic layer including a plurality of projected parts and recessed parts, the projected parts of the ferromagnetic layer serving as recording areas having perpendicular magnetic anisotropy; and
>
> non-recording areas having soft magnetism buried in the recessed parts of the ferromagnetic layer so as to surround the recording areas.

Ishida et al. teaches a master information carrier including a substrate, which has a surface with embossed pattern corresponding to an information signal. Ishida et al., ABSTRACT; see also Fig. 4. The Examiner considered Ishida et al.'s element 41 in Fig. 4 as corresponding to Applicants' claimed non-magnetic substrate. Office Action at 8. However, Ishida et al.'s element 41 in Fig. 4 is not a flat substrate, but rather has "an embossed pattern in the surface [thereof]." Ishida et al., col. 9, ll. 22-24. Therefore, Ishida et al.'s element 41 in Fig. 4 cannot correspond to Applicants' claimed "flat non-magnetic substrate," so that Ishida et al. fails to teach, at least, "a flat non-magnetic substrate," as recited in claim 9. Consequently, Ishida et al. also fails to teach "a ferromagnetic layer formed on the non-magnetic substrate," as recited in claim 9.

Therefore, claim 9 is not anticipated by Ishida et al., and the rejection of claim 9 under 35 U.S.C. §§ 102(a), (b), and (e) should be withdrawn.

In view of the foregoing amendments and remarks, Applicants respectfully request reconsideration and reexamination of this application and the timely allowance of the pending claims.

Please grant any extensions of time required to enter this response and charge any additional required fees to our deposit account 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.

Dated: October 14, 2005

By: ______________________
Qingyu Yin
Ltd. Rec. No.: L0222

Attachment:
Magnetically induced self-organization, by B.A. Jones et al., Journal of Applied Physics, vol. 97, 10J312, 2005 (3 pages).

JOURNAL OF APPLIED PHYSICS 97, 10J312 (2005)

Magnetically induced self-organization

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Self-organized magnetic arrays have received much interest recently. In this work the mechanism of self-ordering is investigated by creating magnetic holes with polystyrene spheres in a thin layer of ferrofluid. When an external field is applied perpendicular to the layer, each hole has an associated magnetic moment due to the Lorentz cavity field. Two sizes of spheres have been measured, 6 and 12 μm, and the degree of order was determined by Fourier analysis. The results show that there is a greater ordering with larger spheres; doubling the diameter of the spheres increases the repulsive force by a factor of 30. © *2005 American Institute of Physics.* [DOI: 10.1063/1.1852452]

INTRODUCTION

Conventional magnetic recording media is quickly approaching the theoretical limit arising due to thermal stability of data. This has generated interest in novel materials such as FePt or CoPt nanoparticles.[1] These nanoparticles are small (<10 nm), with uniform grain size, high coercivities, and the ability to self-assemble into a regular array. In this paper we investigate the mechanism of the self-assembly of such arrays. A comparison between the ordering in a self-organized magnetic array, such as FePt nanoparticles and magnetic holes in a ferrofluid is shown in Fig. 1.

Magnetic holes are created in a thin layer of ferrofluid with monodispersed polystyrene spheres.[2] If an external magnetic field is applied to the layer, each hole acquires a magnetic moment due to the Lorentz cavity field. This magnetic moment μ is given in Eq. (1), where χ_{ff} is the magnetic susceptibility of the ferrofluid, H is the applied magnetic field, and V_{sphere} is the volume of the sphere. This represents a form of magnetic Archimedes principle in that the quasi-diamagnetic moment of the sphere is equal to that of the ferrofluid displaced by the sphere.

$$\mu = -\chi_{ff} H V_{sphere}. \tag{1}$$

When the field is applied parallel to the sample, the spheres align into chains due to the dipole-dipole attraction of the moments on the spheres, but when a field is applied normal to the sample, the spheres repel and self-assemble into a regular hexagonal pattern.

This repulsive energy between the spheres can be measured from the known magnetization of the ferrofluid [Eq. (2)], where E is the repulsive energy between the spheres, $M(H)$ is the magnetization of the ferrofluid, D is the diameter of the spheres, and r is the average separation of the spheres. This repulsive energy is the only factor in the organization, thus challenging the assumption that self-organization occurs due to an energy equilibrium between a repulsive and an attractive force.[3] This is analogous to the hexagonal array of vortices which is found in type-II superconductors, where again only a repulsive force and a boundary gives rise to self-organization.

$$E_{rep} = \boldsymbol{\mu} \,.\, \boldsymbol{\mu}/r^3 = M(H)^2 D^6/r^3. \tag{2}$$

Of course in the limit, the repulsion of the spheres would expel them from the ferrofluid. However for spheres with a typical size of 10 μm, the surface tension at the edge of the sample maintains the concentration.

EXPERIMENT

In this work two samples containing different diameter polystyrene spheres, 6 and 12 μm, were made by depositing 20 μl of 2.5% (25 mg/ml) aqueous solution containing the spheres onto a microscope slide. Once the solute had evaporated, a 100 μl drop of ferrofluid[4] was dropped on top of the

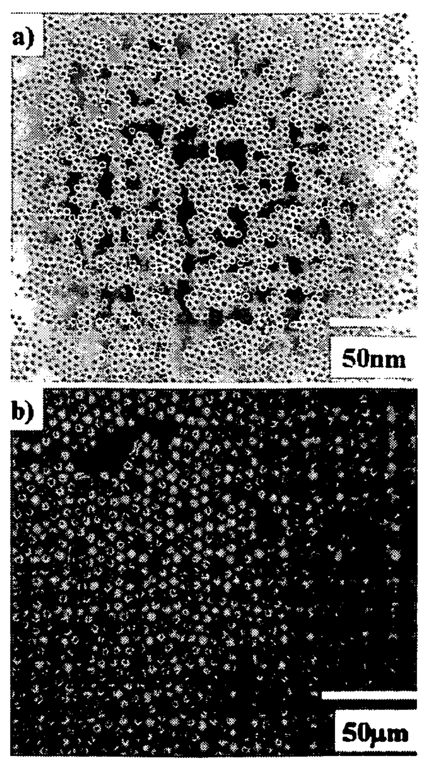

FIG. 1. Comparison of self-ordering: (a) TEM image of FePt nanoparticles, and (b) microscope image of 6 μm polystyrene spheres in a magnetized ferrofluid.

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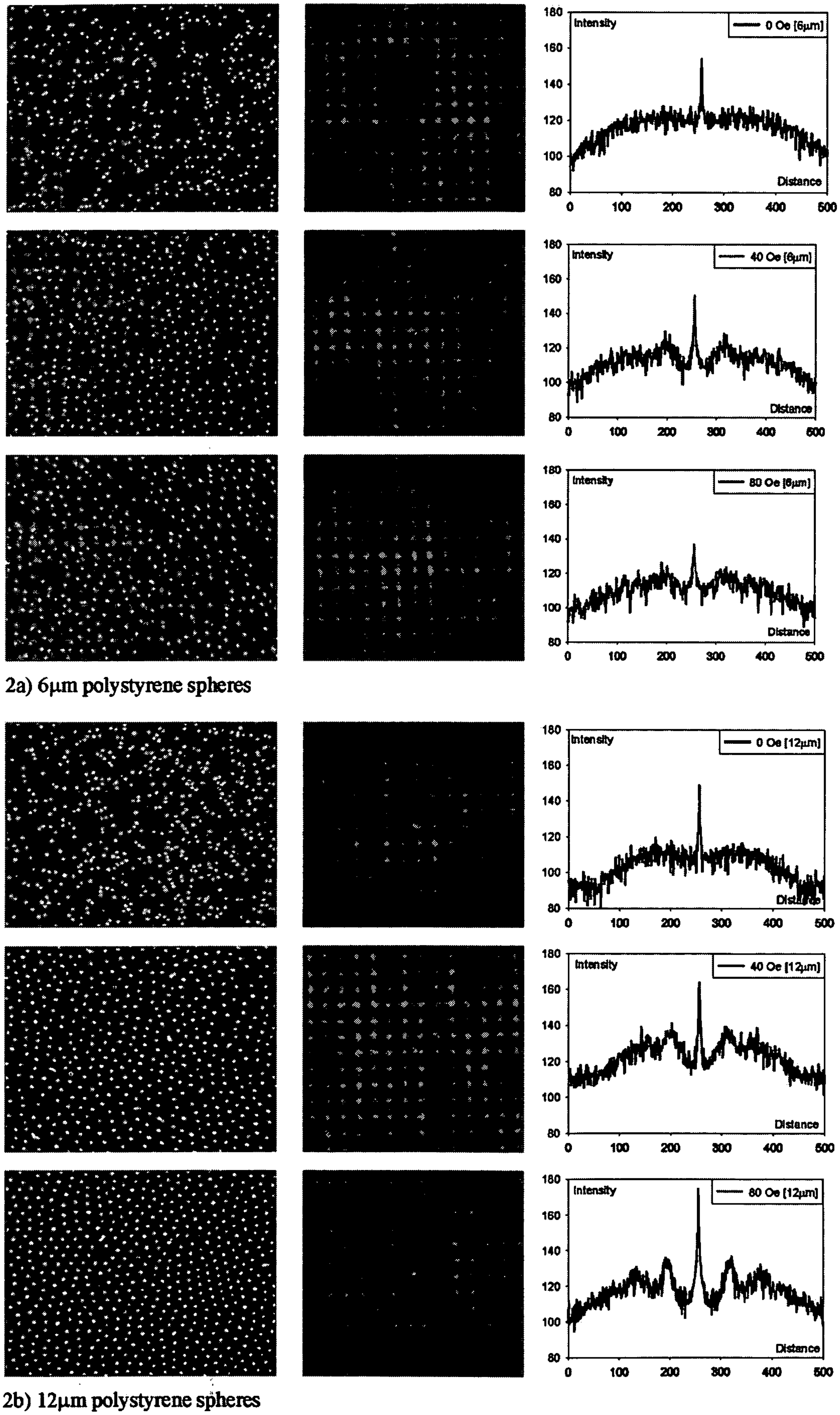

FIG. 2. Results for (a) 6 μm and (b) 12-μm spheres as a function of field. In both (a) and (b) the left column is the original picture of the spheres [depicting an area of (a) 120 μm^2 and (b) 480 μm^2], the middle column the calculated fft, and the right column the plot intensity across the fft. Each row shows the results at a particular field from zero to 80 Oe.

spheres. All volumes were determined using an Eppendorf Research pipette 10–100 μl with an accuracy of 3%. The fluid used was a standard ferrofluid, with M_s=375 Gauss (9.0 memu/mg), as used in loudspeaker damping. The fluid contains magnetite particles with a median diameter of 10 ± 1 nm, dispersed in a PVC plasticizer (specific plasticizer unknown). After the spheres and ferrofluid were mixed, a microscope cover slip was placed on the slide, with a slight pressure to create a monolayer and surface tension at the edges to prevent the spheres from escaping.

Initial measurements investigated the progression of the ordering of 6 μm spheres in a fixed applied field of 80 Oe. From these data a time to equilibrium of 5 min was determined. Another sample containing 6 μm spheres was then magnetized in 10 Oe field steps from the demagnetized state and a series of pictures were taken through a microscope to record the position of the spheres. This was repeated up to a field of 80 Oe. Both of these measurements were then repeated for samples containing 12 μm spheres.

A measure of the ordering as a function of the field was made by taking the fast Fourier transform (fft) of the array in each picture. A computer program, IMAGEJ,[5] calculated the fft of each picture, as well as an intensity profile of the fft image so the sharpness of the image produced by the fft could be found, and hence the degree of ordering.

RESULTS AND DISCUSSION

The results from the initial time experiment indicate that no further ordering occurs after about 3 min for both sizes of spheres, i.e., it takes less than 3 min for the ferrofluid to allow the movement of the spheres into the ordered state. Hence a standard ordering time of 5 min was used in subsequent experiments.

Figure 2 shows a series of images taken from the demagnetized state up to an applied field of 80 Oe for two samples with different sphere diameters: (a) 6 μm and (b) 12 μm. This field value magnetized the ferrofluid to approximately 38% or 142 Gauss (3.4 memu/mg). In Fig. 2 there is the original picture of the polystyrene spheres, the calculated fast Fourier transform of the image and an intensity plot across a cross section of the fft for both sizes of sphere.

Figure 2 clearly shows the hexagonal array created by the spheres by applying a perpendicular field. The fft shows a measure of the ordering, which can be seen from the appearance of the bright fringe arising from any regular array. The line intensity plots gives a clear measure of the fringe as a function of field and thus shows the progression of the ordering with the field.

The magnetic moment and energy of repulsion at 80 Oe was calculated for each sample using Eqs. (1) and (2). The magnetic moment associated with the 12 μm spheres is 10.2×10^{-9} emu and for the 6 μm spheres is 1.28×10^{-9} emu. The average separation between 12 μm spheres is 25 μm and for 6 μm spheres is 20 μm. Therefore, the repulsive energy between the 12 μm spheres is 6.4×10^{-9} ergs and between the 6 μm spheres is 0.2×10^{-9} ergs. Thus, the doubling of the diameter of the sphere increases the energy of repulsion by a factor of 30. The effect of this increase in repulsion can be seen clearly in Figs. 2(a) and 2(b). At the same field of 80 Oe, there is a greater degree of ordering in the 12 μm spheres than there is in the 6 μm spheres.

The results show that there is a measurable increase in the ordering with larger fields. The size of this effect is greater for larger spheres due to an increased repulsive energy. The average separation between the spheres is larger than expected for the 6 μm spheres due to the lower degree of order.

This work has clearly shown that there is an increase in ordering of magnetic holes with increased field due to dipolar interactions. The results show that ordering occurs with only a repulsive force from the dipolar interactions and boundary conditions from the sample preparation. The magnitude of the repulsive force influences the degree of ordering. At equivalent field values, the ordering can vary depending on the size of the hole and hence the repulsive force.

ACKNOWLEDGMENTS

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